PSSSF 1.1.1 VI

Leitch

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAY 24 1988

OFFICE OF
AIR AND RADIATION

MEMORANDUM

SUBJECT: Dose and Risk Estimates for Radioactivity

FROM: Richard J. Guimond, Director /S/
Office of Radiation Programs (ANR-458)

TO: Joseph A. Cotruvo, Director
Criteria and Standards Division, ODW (WH-550D)

Pursuant to your memorandum of April 15, 1988, the Office of Radiation Programs (ORP) recommends the following practices for the radionuclide drinking water regulations.

Man-Made Radionuclides

The International Commission on Radiological Protection (ICRP) dosimetry, including their weighting factors, should be used to obtain effective dose equivalents. This will ensure that these calculations, through reference to ICRP publications, can be readily duplicated.

The risk corresponding to these effective dose equivalents, however, should be that currently in use by ORP. The current fatal cancer risk estimate is 280 per million person-rad for low-LET radiations, an average of linear-absolute and linear-relative risk model estimates in the BEIR III report. In response to the Science Advisory Board (SAB) recommendation on the use of relative risk, a nominal value of 400 per million person-rad has been used in the Background Information Document (BID) for the proposed Low-Level Waste Rule to be published this year. I have also written to the SAB of our intention to use the 400 figure for risk assessment purposes in the new, proposed radionuclide National Emissions Standards for Hazardous Air Pollutants (NESHAPS). Depending on the timing of your rule-making efforts, it may also be desirable for your Office to employ the value of 400.

Alpha Particle Emitters

The use of effective dose equivalents based on ICRP organ doses and weighting factors is also felt to be adequate for alpha emitters. If more recent ICRP recommended effective

2453

1.1.1 0002

dose equivalent factors are available, particularly those based on updated dosimetric models for the transuranic radionuclides, they should be substituted for the original ICRP 30 values.

For those alpha emitters for which individual Maximum Contaminant Levels (MCLs) are to be set, it is recommended that ORP risk estimates specific to each isotope be cited. For your convenience, the lifetime risk (of fatal cancer) associated with the lifetime ingestion (at one picocurie per year (1 pCi/y)) of each of those isotopes listed in your memorandum, is given below:

Lifetime Risk for Lifetime Intake at 1 pCi/y

Isotope	Current[1]	Proposed[2]
Ra-226	5.5×10^{-9}	6.4×10^{-9}
Ra-228	3.9×10^{-9}	4.7×10^{-9}
U-234	3.3×10^{-9}	4.9×10^{-9}
U-238	3.4×10^{-9}	4.9×10^{-9}

[1] Based on current EPA risk methodology as reflected in the 1984 Clean Air Act (CAA) BID.

[2] Modified to reflect SAB recommendation on relative risk.

For the special case of radon-222 decay product inhalation, we recommend that no tissue or organ doses be given since neither the cells at risk nor the dose distribution are well known. Instead the exposure in terms of Working Level Month per year (WLM/y), based on the conversion factors cited in your memorandum of February 9, 1988, should be used. At present, it is recommended that the lifetime risk based on these factors, 6.3×10^{-7} lung cancer deaths per pCi/L, be retained. However, we are also reassessing our estimates of radon risk in light of information contained in the BEIR IV Report, and these may change in the near future.

Uncertainty

Based on information obtained from several sources, the uncertainty associated with the doses from uniformly distributed radioisotopes is believed to be on the order of 2 to 3. The corresponding uncertainty in risk coefficients is estimated to be about 3, yielding an overall uncertainty of 4 to 5 in the risk estimates. Thus, for a risk estimate R, the uncertainty interval would range from R/5 to 5R.

For those isotopes nonuniformly distributed in the whole-body, the uncertainty is difficult to quantify. In general, uncertainties in organ doses and risks per unit dose are likely to be larger than for the whole-body, leading in some cases to a substantially larger uncertainty in risk. In the case of alpha emitting radionuclides, there may be an additional uncertainty, moreover, with respect to the relative effectiveness of low- and high-LET radiations in causing cancer.

Additional Considerations

1. The term "man-made" in connection with the beta-gamma emitters should be eliminated. The term has caused confusion because many of the alpha emitters can also be deemed "man-made." For example, the Advance Notice of Proposed Rulemaking (ANPRM) includes Pu-239 and Am-241, in what was intended to be solely the beta-gamma category.

2. Some consideration should be given to excluding the beta-gamma emitters in the neptunium series from the beta-gamma category. The ANPRM does this for the other three primordial series, and the same rationale should be applied to all naturally occurring series, each of which contains alpha emitters.

3. Both the alpha and beta-gamma screens should be retained in order to reduce the cost and complexity of monitoring. Whether these are defined as screens or MCLs would appear to be immaterial since, presumably, a water supply in conformance to them would be exempt from further requirements.

cc: Edward V. Ohanian (WH-550D)
Craig Vogt (WH-550D)
Susan MacMullin (WH-550D)
David E. Janes (ANR-461)
J. William Gunter (ANR-460)
H. Michael Mardis (ANR-464)
Wayne A. Bliss, ORP/LVF
Charles R. Porter, EERF
Division Directors, Regions 1-10

S/1 Control to ASD.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR 15 1988

OFFICE OF WATER

MEMORANDUM

SUBJECT: Risk Estimates for Radionuclides by Several Methods

FROM: Joseph A. Cotruvo, Ph.D., Director
Criteria and Standards Division, ODW (WH-550D)

TO: Richard J. Guimond, Ph.D., Director
Office of Radiation Programs (ANR-460)

Thank you for your April 8, 1988 memorandum entitled "MCLs for 'Manmade Radionuclides' in Drinking Water".

This memorandum and accompanying tables present risk estimates for radon 222, radium 226, radium 228, natural uranium and the beta/gamma emitting radioisotopes found in drinking water. The memorandum and tables provide three different estimates, based upon the approaches used in the ANPRM for Radionuclides in Drinking Water (51 FR 34836, September 30, 1986), by the ICRP, and by the ORP in conjunction with Oak Ridge National Laboratory. Your advice and concurrence regarding risk estimates and their associated uncertainties are requested for use in the forthcoming Notice of Proposed Rulemaking for Radionuclides in Drinking Water.

The SAB, in its critique of the ANPRM, recommended that ICRP weighting factors be used rather than those of EPA (ORNL/ORP). They observed that the results obtained for drinking water are generally not altered in a significant way, except perhaps where radiation to bone is a factor. Although they did not comment in writing as to whether the ORNL/ORP or the ICRP methodology should be used, they observed in their deliberations that the ORNL/ORP methodology is not widely used outside of the Agency and that it is difficult to obtain the supporting documentation for it. In the ANPRM, we asked the questions (#5, page 34348) "In the calculation of the

APR 19 1988

effective dose equivalent, should the weighting factors developed by ICRP or those developed by EPA based on BEIR III be used? Why?" The response by the public was almost unanimous in the opinion that the ICRP factors (and methods) should be employed. For these reasons, it is felt that the most appropriate approach to use in the proposed regulations is the ICRP approach.

Table I compares the results of these methods. The "ANPRM" approach is described in Appendix D of the ANPRM. Briefly, the dose equivalent associated calculations were done at Oak Ridge National Laboratory using the modified ICRP 30 model. The weighting factors were derived by EPA based on BEIR III. The model uses an early version of a computer analysis called "RADRISK", a later version of which is described in paragraph 5 of this memorandum.

Radionuclide concentrations (in pCi/L at 2L/day) that are expected to result in an effective dose equivalent of 4 mrem/year are also shown in Table I under the heading "ICRP". These data result from calculations based on ICRP publications 26 and 30. ICRP publication 26 indicates that this rate of exposure results in a lifetime risk of 3.5×10^{-5} for a 70 year exposure. This risk level was derived from a risk estimate for radiation workers, and there is considerable uncertainty involved in applying it to the general population.

The "ORNL/ORP" approach uses an updated version of the computer program "RADRISK" which relies upon dosimetric models recommended in 1979 by ICRP. In these calculations, the ingrowth and pharmacokinetics of daughter products after ingestion of the parent into the body are explicitly considered in the dose-rate calculations.

Table II presents a range of possible MCLs for each radionuclide group and indicates the corresponding lifetime risk, as calculated using the ICRP and ORNL/ORP methodologies.

Table III presents the concentrations of selected beta and/or gamma emitting radionuclides that correspond to: A) the limits currently in effect, B) those proposed in the ANPRM (it is our understanding that ORP currently recommends slightly different values for the MCLs based on improvements in the ORNL/ORP calculations), and C) those calculated using ICRP methodology. It should be noted that there is generally a large increase in going from the limits currently in effect (column A) to those for the latter two categories (column B and C). These two categories, however, are usually the same,

or nearly the same. Accordingly, there should not be a large difference in the MCLs for most beta/gamma emitting radioisotopes if the ICRP methodology is used instead of the ORNL/ORP methodology.

EPA indicated in the ANPRM that the overall uncertainty in the risk estimates for radionuclides drinking water is a factor of approximately four or five. A question has arisen regarding the basis of these values and whether they are sufficiently conservative.

In the proposed regulations, we are considering expressing the risk associated with each radionuclide for which an MCL is promulgated as a range. In addition, the risk estimates shown under the ICRP or the ORNL/ORP columns of Table I would be given as representing the central tendency. The ORNL/ORP calculations give substantially the same concentrations for a given dose, and the associated uncertainty in the corresponding risk value should be nearly the same even if the ICRP values are used. Your advice is requested as to the risk and associated uncertainty values to use in conjunction with the MCL values to be stated in the Notice of Proposed Rulemaking.

cc: Craig Vogt
Susan MacMullin

TABLE I

LIFETIME RISK (R) PER 4mrem/year and PER pCi/L*

	ANPRM**			ICRP			ORNL/ORP		
	pCi/4mrem	R/4mrem	R/pCi/L	pCi/4mrem	R/4mrem	R/pCi/L	pCi/4mrem	R/4mrem	R/pCi/L
Ra 226	6	5.3E-5	8.8E-6	4	3.5E-5	8.8E-6	7.4	3E-5	4E-6
Ra 228	11	6.9E-5	6.6E-6	4	3.5E-5	8.8E-6	11.6	3.3E-5	2.8E-6
N. Uran.+	40	5.6E-5	1.4E-6	20	3.5E-5	1.8E-6	43	2.7E-5	6.2E-7
Rn 222++	400***	4E-5***	1E-7***	56-170	3.5E-5	2.1-6.2E-7			6.3E-7
Beta/Gamma		8E-5			3.5E-5			aprx. 8E-5	

* Dose rate = 4 mrem per year for 70 years. Thus, "pCi/4mrem" indicates the number of pCi per liter that result in a 4 mrem annual dose at a consumption rate of 2L/day for 70 years. The column "R/pCi" indicates lifetime risk from exposure to water with radionuclide activity equal to 1 pCi/L. The "R/4mrem column indicates the lifetime risk R that results from a dose rate of 4 mrem/yr. for 70 years.

** Radionuclides in Drinking Water (51 FR 34836)

*** These values are quite approximate and are taken from ANPRM, Table 10.

\+ For the ICRP and ORNL/ORP calculations, the average of the values for ^{234}U and ^{238}U were used. These values are within 10% of each other.

++ These values arise from the radon, originally present in the drinking water, degassing into the indoor air.

TABLE II

MCL Options and Associated Risks Using ICRP and ORNL/OPR Methodologies

	MCL (pCi/L)	Lifetime Risk (x10E-5) ICRP	ORNL/ORP
Ra 226	2	1.7	0.8
	3	2.6	1.2
	4	3.5	1.6
	5	4.4	2.0
	6	5.2	2.4
	8	7.0	3.2
Ra 228	2	1.7	0.5
	3	2.6	0.8
	4	3.5	1.1
	5	4.4	1.4
	6	5.2	1.6
	8	7.0	2.2
Nat. Uranium*	30	5.4	1.9
	40	7.2	2.5
	60	11	3.8
	100	18	6.3
	120	22	7.6
Rn 222**	200	4-13	13
	250	5-15	16
	500	10-31	32
	1000	21-62	63
	2000	42-120	130
	3000	63-190	190
Beta/Gamma: 2 mrem/yr		1.7	4
4 mrem/yr		3.5	8
6 mrem/yr		5.2	12
8 mrem/yr		7	16
10 mrem/yr		8.5	20

* Selection of an appropriate MCL also must consider the chemotoxicity of this radionuclide

** ORP's radon action level (4 oCi/L_{air}) constitutes a risk of 2x10-2 (approximate).

TABLE III

Comparison of Three Methods of Calculating MCL's for beta- and gamma- emitting Radioisotopes in Drinking Water

A. Current MCLs (as prescribed in the 1976 Interim Regulations) - Annual dose equivalent to the total body or any internal organ shall not exceed 4 millirem.

B. MCLs in ANPR - Risk is equal to that from an annual effective dose equivalent of 4 millirem (EPAs weighing factors, etc.)

C. Proposed MCLs - Annual effective dose equivalent shall not exceed 4 millirem (ICRP weighting factors & ICRP methodology).

	Limits in pCi/Liter		
	A	B	C
Isotope	Current	Proposed in ANPR	ICRP
H^{3}	20,000	90,000	90,000
Ca^{45}	10	2,000	2,000
Co^{60}	100	200	200
Zn^{65}	300	400	400
Sr^{89}	20	900	600
Sr^{90}	8	50	40
Y^{90}	60	1,000	500
Y^{91}	90	1,000	600
Mo^{99}	600	2,000	1,000
I^{131}	3	700*	100
Cs^{134}	80	80	70
Cs^{137}	200	100	100
Ce^{141}	300	4,000	2,000

* ORP has indicated that the large value for ^{131}I is due to the assumed pharmacokinetic modelling.